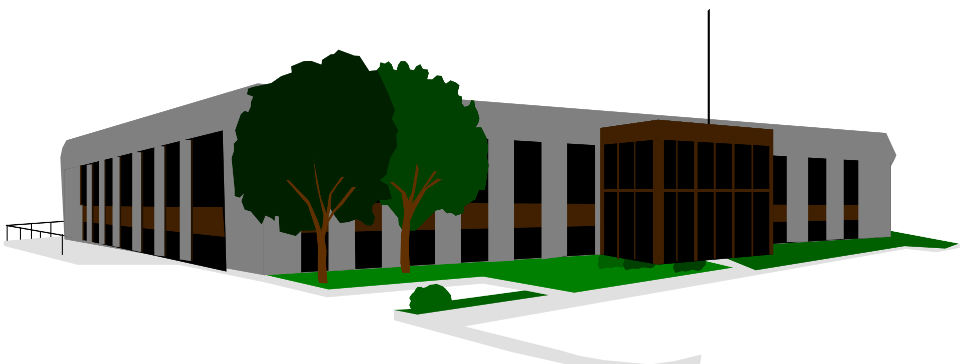
INDOOR AIR QUALITY ASSESSMENT

William E. Welch, Sr. Elementary School
3 Swampscott Avenue
Peabody, Massachusetts



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment

July, 2000

Background/Introduction

At the request of a concerned citizen's group, an indoor air quality assessment was conducted at the Welch Elementary School in Peabody, Massachusetts. This assessment was conducted by the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA).

The school was visited by Michael Feeney, Chief of BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program, on May 5, 2000 to conduct an indoor air assessment. Mr. Feeney was accompanied by Cory Holmes, Environmental Analyst, ER/IAQ, BEHA. This request was prompted by indoor air quality issues concerning potential impacts related to construction of a golf course on property adjacent to the school. Methods to prevent renovation/construction generated pollutants from migrating into occupied areas of the building were previously recommended, see Appendix A (MDPH, 2000).

The school is a two-story brick building constructed in 1974. The second floor consists of general classrooms, occupational therapy room, art room and resource room. The first floor is made up of general classrooms, kitchen, cafeteria, gymnasium, library and office space.

Methods

Air tests for carbon dioxide were taken with the Telaire, Carbon Dioxide Monitor and tests for temperature and relative humidity were taken with a Mannix, TH Pen PTH 8708 Thermo-Hygrometer.

Results

The school houses grades K-5, with a student population of 432 and a staff of approximately 50. The tests were taken during normal operating hours at the school. Test results appear in Tables 1-4.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in eight of twenty-six areas surveyed, which is indicative of a ventilation problem in these areas of the school. It should be noted however, that a number of areas throughout the school had open windows or were sparsely populated during the assessment, which can greatly contribute to reduced carbon dioxide levels.

Fresh air in classrooms is supplied by a unit ventilator (univent) system (see Picture 1). Univents draw air from outdoors through a fresh air intake located on the roof or exterior walls of the building (see Pictures 2 & 3) and return air through an air intake located at the base of each unit (see Figure 1). Fresh air and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. Univents were deactivated in the majority of classrooms surveyed. BEHA staff activated several of these units to observe function using univent power switches (see Tables).

Obstructions to airflow, such as books, papers and posters on top of univents, as well as bookcases, tables and desks in front of univent returns, were seen in a number of classrooms (see Picture 1). To function as designed, univents and univent returns must remain free of obstructions. Importantly, these units must be activated and allowed to operate during hours of school occupation.

The mechanical exhaust ventilation system in each classroom consists of ceiling-mounted vents located inside of the classroom coat closets (see Picture 4) and powered by roof top exhaust motors (see Picture 5). Coat closet doors are undercut to allow exhaust air to be pulled into the closet and out the vent (see Picture 6). This design allows for these vents to be easily blocked by stored materials. In a number of classrooms, vents were blocked with books, boxes and other obstructions. As with the univents, many of the exhaust vents were not operating at the time of the assessment. BEHA staff examined exhaust motors on the roof and determined that several motors were not functioning (see Tables under "Roof Notes"). In order to function as designed, exhaust vents must also be activated, cleared and remain free of obstructions.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings ranged from 68^{o} F to 78^{o} F, which was very close to the BEHA recommended range for comfort. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. Temperature complaints were reported to BEHA staff in a number of areas (see Tables). Temperature control is difficult without a properly functioning ventilation system. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity in the building ranged from 28 to 38 percent, which was below the BEHA recommended comfort range in all areas. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Several areas had water stained ceiling tiles (see Tables/Picture 7). Water-damaged ceiling tiles can provide a source of mold and mildew and should be replaced after a water leak is discovered and repaired. Mold can be an eye and respiratory irritant to certain sensitive individuals. Classroom 14 contained a water-stained ceiling tile with possible mold growth (see Picture 8).

Plants were noted in several classrooms. Plants can be a source of pollen and mold, which can be a respiratory irritant to some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold (see Picture 9). Several classrooms contained plants in window planters. Window planters are designed to be mounted on the outside of windows and usually do not have drip pans. The lack of drip pans can lead to water pooling and mold growth on windowsills when used indoors. Windowsills have the potential to become colonized by mold growth and serve as a source of related odors. Several classrooms had plants without drip pans resting on newspaper or other paper material (see Picture 10). If this material becomes wet repeatedly, it can also become colonized by mold.

In a number of areas caulking around the interior and exterior windowpanes was loose, missing or damaged (see Pictures 11). Repairs of window leaks are necessary to prevent water penetration. Repeated water damage can result in mold colonization of window frames, curtains and items stored on or near windowsills.

Water intrusion was evident in the multipurpose room by the presence of efflorescence (e.g., mineral deposits) noted on the wall. As moisture penetrates and works its way through the plaster, it leaves behind these characteristic mineral deposits. Repeated water penetration can lead to mold growth and associated odors.

Room 14 contained a large fish tank that was green with algal growth (see Picture 12). Aquariums should be properly maintained to prevent microbial/algal growth as they can emit unpleasant odors into the classroom.

Other Concerns

Several conditions that can potentially affect indoor air quality were also identified. Accumulated chalk dust was noted in several classrooms. Chalk dust is a fine particulate, which can become easily aerosolized and serve as an eye and respiratory irritant. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), (e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999). These products can be irritating to the eyes, nose and throat.

The teacher's workroom contains a lamination machine and photocopiers. Lamination machines give off odors. Volatile organic compounds (VOCs) and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). No local exhaust ventilation is provided for this room. Without adequate exhaust ventilation, pollutants produced by office equipment can build up.

Cleaning products were found on counter-tops and beneath sinks in a number of classrooms. These items can contain chemicals, which can be irritating to the eyes, nose and throat and should be stored properly and out of reach of students.

Accumulated dirt/dust/and plant debris was noted within the univents in several classrooms (see Tables). These can be easily aerosolized and distributed throughout classrooms via the air stream of the univent air diffuser. The interior of univents should be cleaned prior to activation.

Also of note was the amount of materials stored inside classrooms (see Picture 13). In several areas, items were observed piled on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items, (e.g., papers, folders, boxes, etc.) make it difficult for custodial staff to clean in and around these areas. Dust can be irritating to eyes, nose and respiratory tract. These items should be relocated and/or should be cleaned periodically to avoid excessive dust build up. In addition, a number of exhaust vents in classrooms were noted with accumulated dust. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize household type dust particles.

Univents were equipped with metal racks, into which filter materials are cut to fit (see Picture 14). The material used for filtering in these metal racks provides minimal filtration of respirable particulates that can be distributed by univents. Univents should be equipped with filters that strain particulates from airflow. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed in univents. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce univent airflow through increased resistance. Prior to any increase of filtration, a ventilation engineer should be consulted as to whether univents can maintain function with more efficient filters.

Several classrooms have window mounted air-conditioning units that are equipped with filters, which should be changed as per the manufacturer's instructions to avoid the build up and re-aerosolization of dirt, dust and particulate matter. The filter of the unit in classroom 9 was inspected by BEHA staff and had heavy dust accumulation (see Picture 15).

Several wasp and hornet's nests were noted outside of classroom 25 (occupational therapy) (see Picture 16). These items should be removed in a manner as to not introduce pests and/or pesticides into the school and its ventilation system.

The hallway door noted in Picture 17 was damaged; the core appeared to consist of a white, chalky material, which may contain asbestos. Intact asbestos-containing materials do not pose a health hazard if they are not disturbed. If damaged, asbestos-containing materials can be rendered friable and become aerosolized. Friable asbestos is a chronic (long-term) health hazard, but will not produce acute (short-term) health effects (e.g., respiratory symptoms, headaches, etc.) that are associated with buildings that are believed to have indoor air quality problems. Pursuant to the Asbestos Hazard Emergency Response Act (AHERA), school systems are required to examine asbestos containing materials on a three-year cycle for signs of friable dust or damage (US EPA, 1988). Where asbestos-containing materials are found damaged, they should be removed in a manner consistent with Massachusetts asbestos remediation laws (MDLI, 1993). To determine if this door contains asbestos, a review of the school's AHERA plan, blueprints, purchase orders or contacting the manufacturer is recommended.

Conclusions/Recommendations

In view of the findings at the time of our inspection, the following recommendations are made:

1. Implement the corrective actions recommended concerning golf course construction (see Appendix A) (MDPH, 2000).
2. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy independent of classroom thermostat control.
3. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.
4. Inspect exhaust motors and belts for proper function, repair and replace as necessary.
5. Remove all blockages from univents and exhaust vents.
6. Once both the fresh air supply and exhaust ventilation are functioning, the ventilation system should be balanced by an HVAC engineer.

7. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
8. Repair roof leaks and replace any water-stained ceiling tiles. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
9. Repair/replace loose, missing or damaged window caulking building-wide to prevent water penetration through window frames.
10. Keep plants away from univents in classrooms. Ensure plants have drip pans, examine drip pans for mold growth and disinfect areas with an appropriate antimicrobial where necessary. Consider discontinuing the use of window planters inside the building.
11. Clean and maintain aquariums to prevent bacterial/mold growth and associated odors.
12. Examine interior and exterior of multipurpose room for breaches of the building envelope and seal to prevent water penetration and subsequent damage and/or mold growth.
13. Clean chalkboards and trays regularly to avoid the build-up of excessive chalk dust.

14. Change or clean filters for univents as per the manufacturer’s instructions or more frequently as needed to prevent the re-aerosolization of dirt, dust and particulate matter. Consider replacing metal grates for univents with disposable filters. Examine univents to ascertain whether filters with an increased dust spot efficiency that fit univent filter racks flush can be installed.
15. Clean and vacuum interior of univents prior to operation to avoid the re-aerosolization of accumulated dirt, dust and debris.
16. Examine the feasibility of providing local exhaust ventilation for areas that contain lamination machines and photocopiers.
17. Remove hornet/wasp’s nests outside of classroom 25 in a manner as to not introduce pests and/or pesticides into the school and its ventilation system.
18. Clean chalkboards and trays regularly to prevent the build-up of excessive chalk dust.
19. Change filters in window-mounted air conditioners as per the manufacturer’s instructions to prevent the re-aerosolization of dirt, dust and particulate matter.
20. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
21. Store chemicals and cleaning products properly and out of the reach of students.
22. Determine if hallway door in Picture 15 is made of asbestos-containing material. If found to contain asbestos, remediation must be done in a manner consistent with Massachusetts asbestos remediation and hazardous waste disposal laws.

References

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Picture 1

Classroom Univent: Note Materials Obstructing Air Diffuser (Top of Unit)

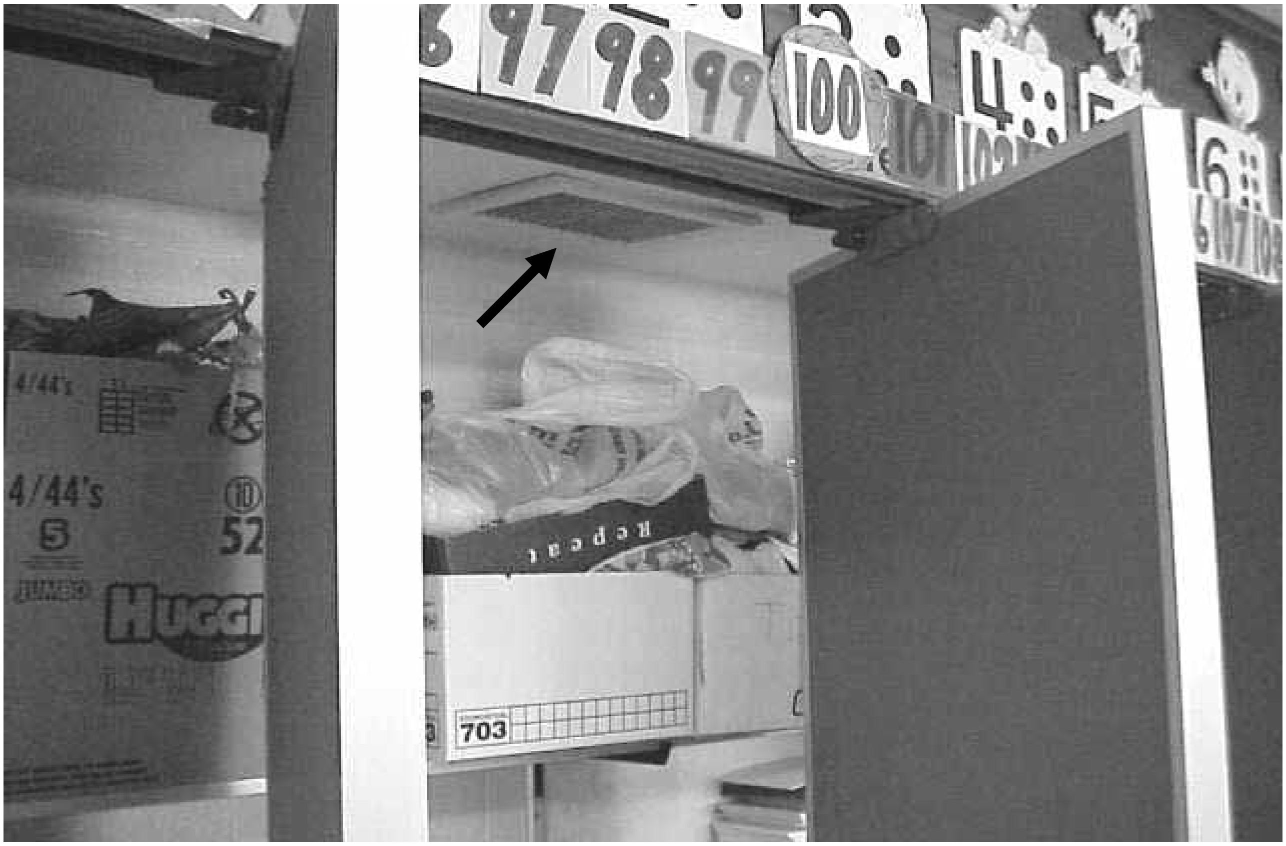
Picture 2

Univent Fresh Air Intakes on Exterior of Building

Picture 3

Rooftop Univent Fresh Air Intake for Interior Classrooms

Picture 4

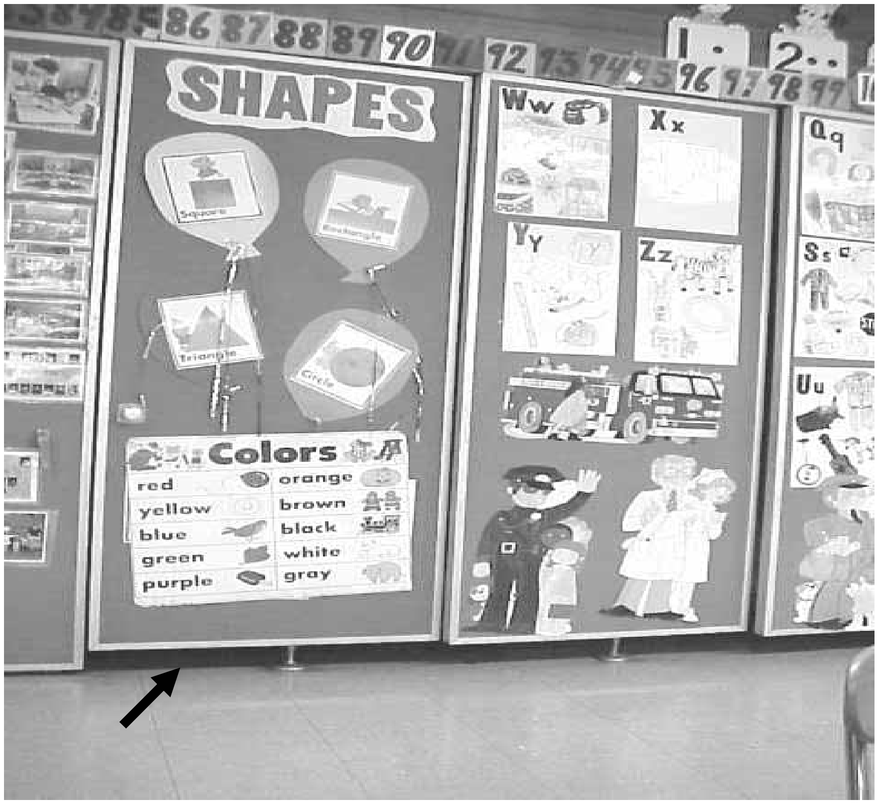


Ceiling-Mounted Exhaust Vent Noted in Classroom Coat Closets

Picture 5

Rooftop Exhaust Motors: Note that 17 of 22 of These Motors Were Operating During the Assessment

Picture 6

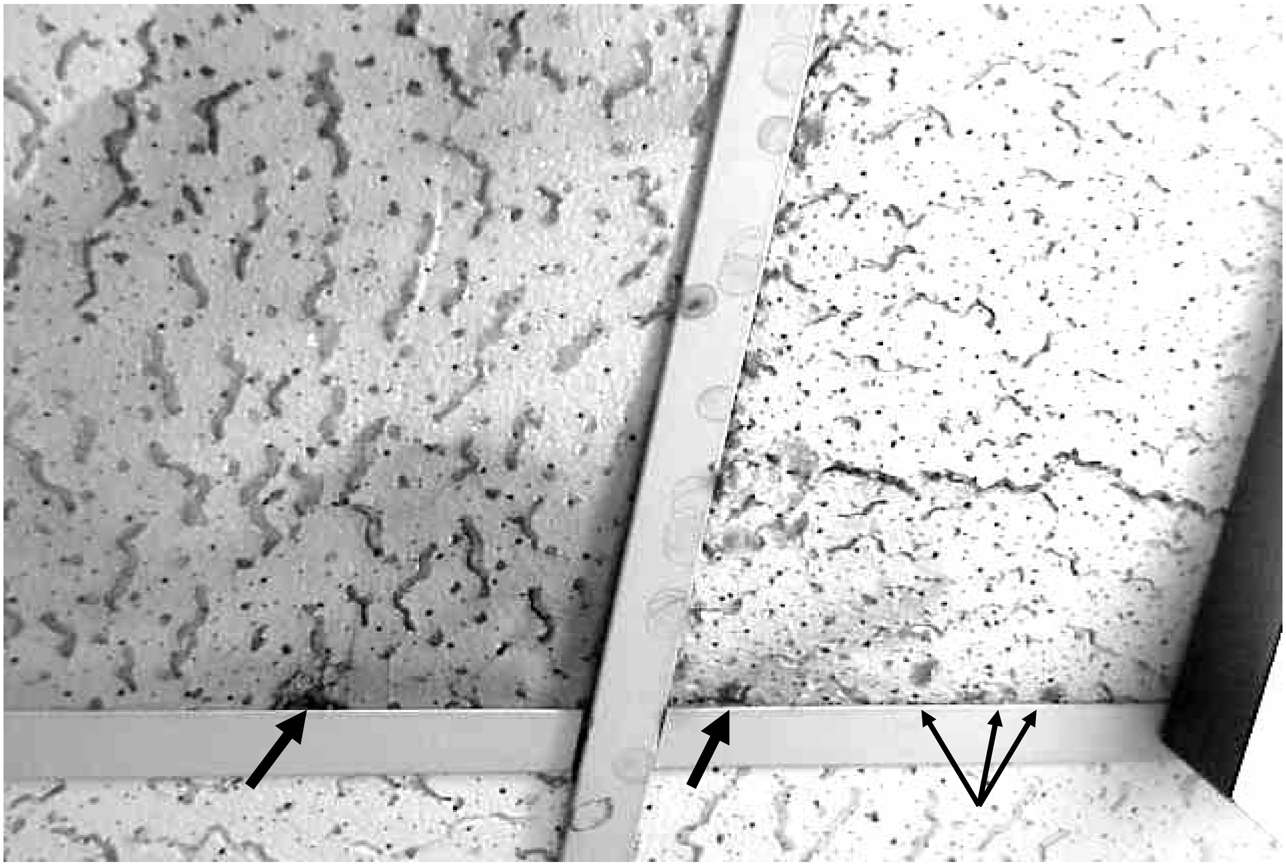


Doors of Classroom Coat Closets: Note Doors are Undercut to Facilitate Exhaust Ventilation

Picture 7

Water-Stained Ceiling Tile in Classroom

Picture 8



Possible Mold Growth on Classroom Ceiling Tile

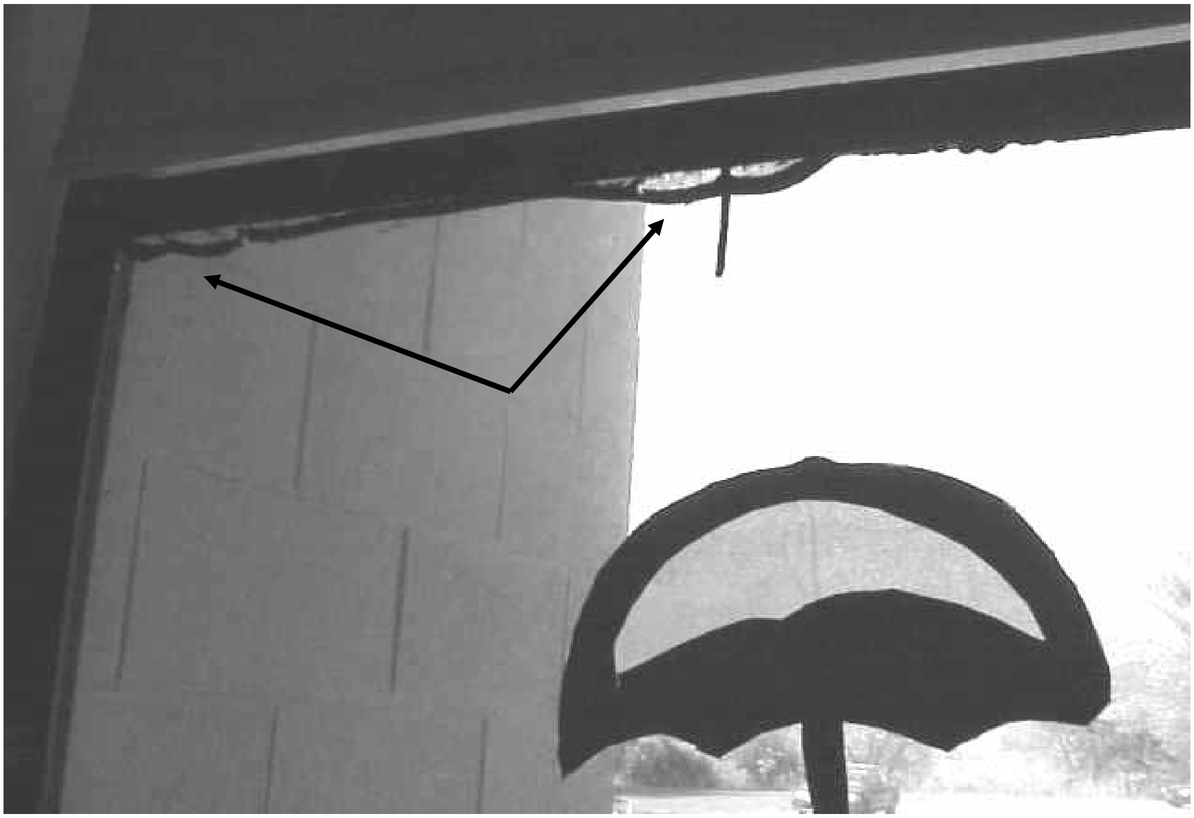
Picture 9

Plants and Other Materials on Classroom Univent

Picture 10

Plant on Paper in Classroom: Note Plant is not Equipped With Drip Pan

Picture 11



Failing Window Caulking around Classroom Window

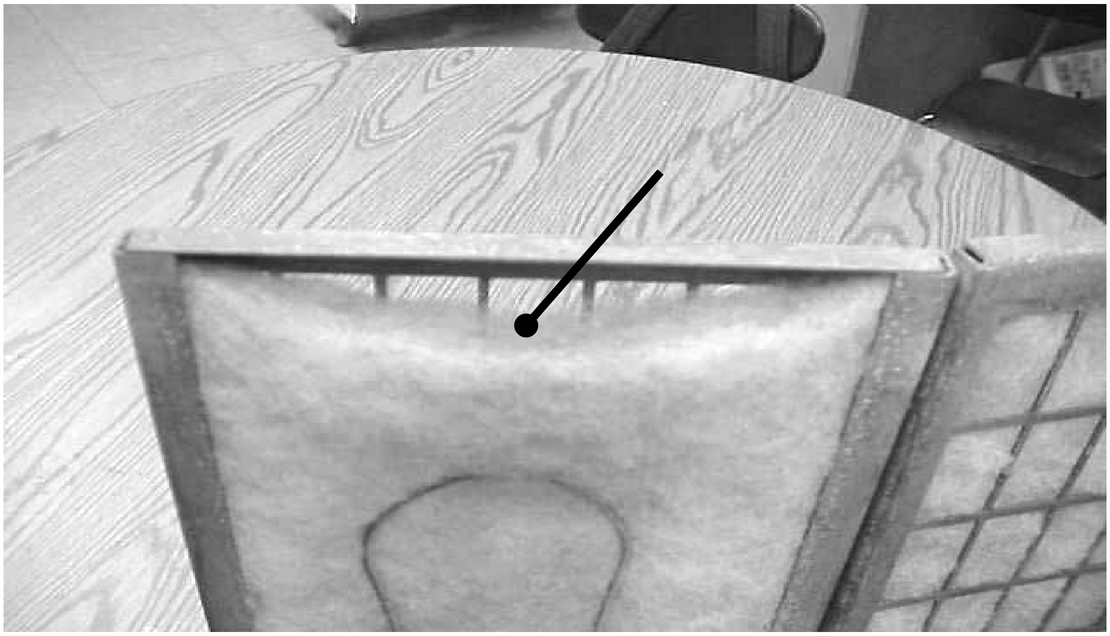
Picture 12

Aquarium with Algal Growth in Classroom 14

Picture 13

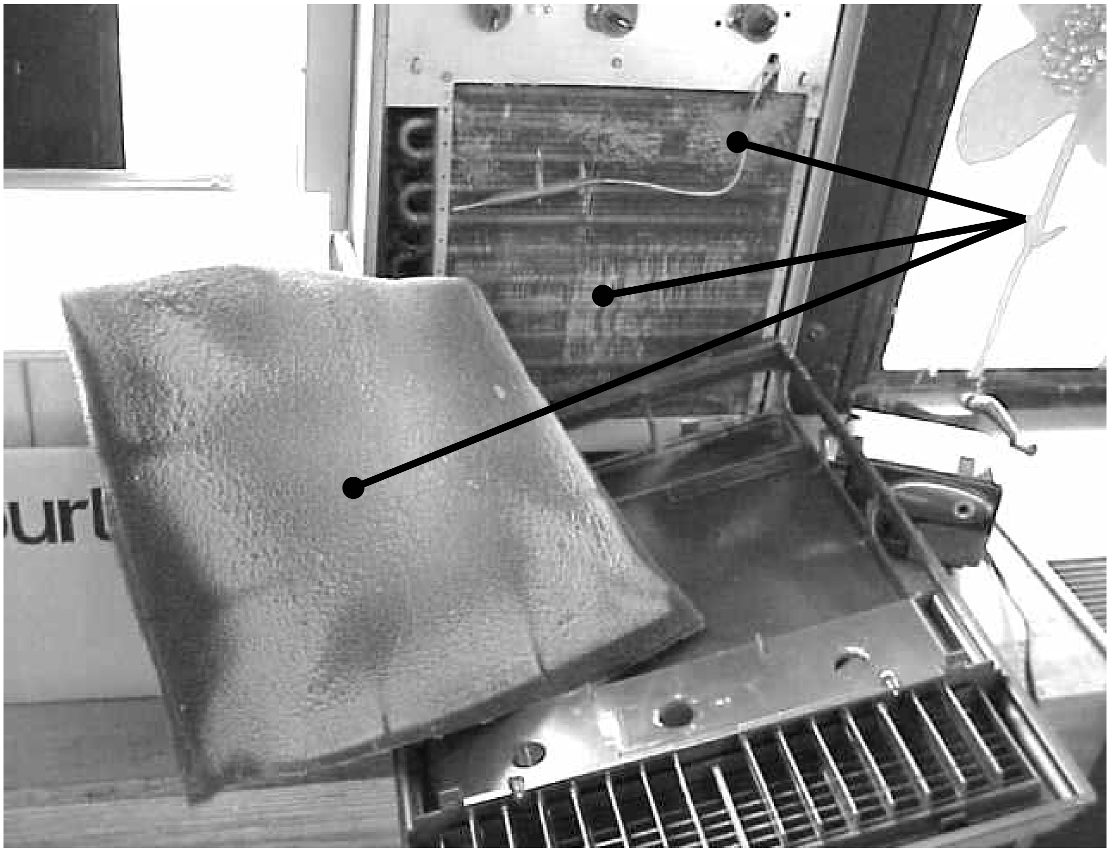
Accumulated Materials in Classroom

Picture 14



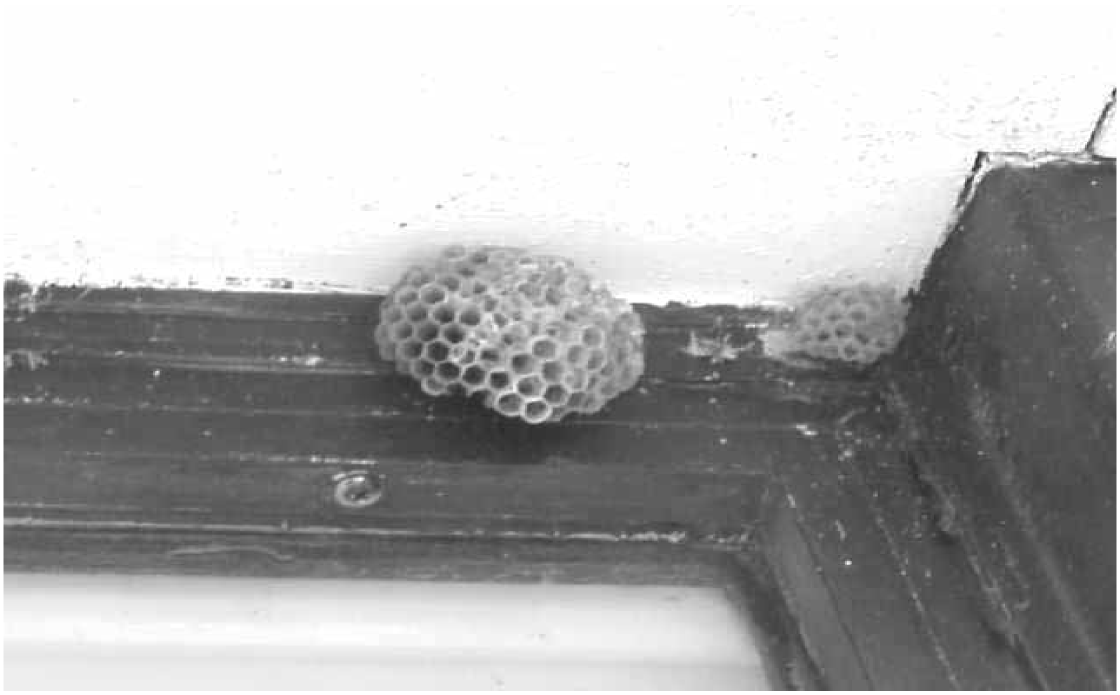
Metal-Framed Univent Filter: Note Spaces Allowing Materials to Bypass the Filter Media

Picture 15



Accumulated Dirt and Dust on Air-Conditioner Filter and Cooling Vents

Picture 16



Hornet's Nests Outside of the Occupational Therapy Room (Classroom 25)

Picture 17

Possible Asbestos-Containing Material in Damaged Door

TABLE 1

Indoor Air Test Results –Welch Elementary School, Peabody, MA – May 12, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	412	69	31					
Room 14	646	71	32	13	yes	yes	yes	exhaust off, univent return blocked by cabinet, fish tank-algae growth, missing/damaged caulking, 16+ CT, possible mold growth, door open
Room 16	420	70	32	0	yes	yes	yes	univent off-air diffuser blocked by items-activated, exhaust off, spaces between filters, door open, dirt/dust accumulation in univent interior
Room 16 Boy's Restroom							yes	
Room 16 Girl's Restroom							yes	
Room 6	500	72	31	20	yes	yes	yes	univent and exhaust off, window and door open, cleaning product on counter
Room 8	612	75	28	20	yes	yes	yes	univent off, window and door open
Room 4				0	yes	yes	yes	flowering plant near univent, items on univent, plant matter in univent air diffuser, plant-no drip pan-on newspaper, lots of stored paper

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results –Welch Elementary School, Peabody, MA – May 12, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
								materials
Room 12 (Computer Room)					yes	yes	yes	24 computers, 6 printers, door open
Room 10	854	77	28	24	yes	yes	yes	door open
Room 18	556	78	24	4	yes	yes	yes	exhaust off, window and door open, 4 CT
Room 20	588	74	27	26	yes	yes	yes	univent and exhaust off, window open, 15+ plants, plants without drip pans-on paper, 1 CT, window planter
Room 26	1010	75	32	2	yes	yes	yes	univent and exhaust off, window and door open
Room 22	700	77	26	0	yes	yes	yes	univent and exhaust off, books/boxes on univent
Room 24	642	75	27	2	yes	yes	yes	exhaust off, door open
Roof Notes								2 out of 3 exhaust vents operating on upper roof, 15 out of 19 exhaust vents operating on lower roof, hornet/wasp's nests outside of room 25 (OT)

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CT = water-damaged ceiling tiles

Comfort Guidelines

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	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results –Welch Elementary School, Peabody, MA – May 12, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Teacher's Workroom						yes	no	laminator, photocopier, vent off
Room 11								sand in univent
Room 13	617	71	32	4	yes	yes	yes	exhaust off, door open, aquarium
Room 15	528	69	33	2	yes	yes	yes	exhaust off, door open, 2 CT, chalk dust
Multipurpose Room	602	68	38	21	no	yes	yes	univent off, efflorescence
Room 7	712	71	34	18	yes	yes	yes	univent and exhaust off, window and door open, chalk dust
Room 5	613	72	33	16	yes	yes	yes	univent and exhaust off, window open, plant
Room 3	981	73	33	21	yes	yes	yes	exhaust off, window and door open, spray cleaning products
Room 2	988	74	32	18	yes	yes	yes	exhaust off, window and door open, chalk dust
Room 1	607	74	31	17	yes	yes	yes	exhaust off, window and door open, chalk dust, spray cleaning products
Cafetorium	842	71	35	100+	no	yes	yes	univent off, exhaust off-occluded by dust, door open

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

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	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 4

Indoor Air Test Results –Welch Elementary School, Peabody, MA – May 12, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 11	791	72	34	7	yes	yes	yes	
Room 9	815	73	36	22	no	yes	yes	poster board on univent, 3 CT, window mounted air conditioner-filters, door open
Room 19	916	73	34	20	yes	yes	yes	univent off, window open, chalk dust, 1 CT, 1 missing ceiling tile
Room 25	1150	73	34	5	yes	yes	yes	univent and exhaust off, chalk dust, efflorescence, tires, photocopier, door open
Room 17 (Art Room)	531	72	30	0	yes	yes	yes	univent and exhaust off, window and door open, chalk dust, hallway door-
Room 21	702	72	31	28	yes	yes	yes	univent and exhaust off-back-draft from exhaust, window open, chalk dust
Room 23	493	70	33	0	yes	yes	yes	univent and exhaust off, window open

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CT = water-damaged ceiling tiles

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